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A LANCHESTER - BASED MODEL FOR INVESTIGATING  
ALTERNATIVE AMBUSER DEPLOYMENT TACTICS IN  
SMALL UNIT AMBUSHES

Seri Riddhiroj

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Monterey, California



THESIS

A LANCHESTER - BASED MODEL FOR INVESTIGATING  
ALTERNATIVE AMBUSER DEPLOYMENT TACTICS IN  
SMALL UNIT AMBUSHES

by

Seri Riddhiroj

June 1974

Thesis Advisor:

G. F. Lindsay

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Lanchester - Based Model for Investigating Alternative Ambusher Deployment Tactics in Small Unit Ambushes		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis June 1974
7. AUTHOR(s) Seri Riddhiroj		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		12. REPORT DATE June 1974
		13. NUMBER OF PAGES 55
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Lanchester's Equations Ambush		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Schaffers extensions to Deitchman's mixed Lanchester combat model are applied to investigate various ambush deployment schemes. Five schemes are considered for ambushing a convoy at a curve in a road. The ambushes studied are initiated by a claymore firing. Results suggest that the ambushing force is more effective in deployments which		





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permit fire down, rather than across, the road.





A Lanchester - Based Model for Investigating Alternative  
Ambusher Deployment Tactics in Small Unit Ambushes

by

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requirements for the degree

MASTER OF SCIENCE IN OPERATIONS RESEARCH

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NAVAL POSTGRADUATE SCHOOL  
June 1974



## ABSTRACT

Schaffers extensions to Deitchman's mixed Lanchester combat model are applied to investigate various ambush deployment schemes. Five schemes are considered for ambushing a convoy at a curve in a road. The ambushes studied are initiated by a claymore firing. Results suggest that the ambushing force is more effective in deployments which permit fire down, rather than across the road.



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## I. SUMMARY

The purpose of the study reported in this thesis was to identify and relate the major variables of ambush combat engagements in such a way that different ambusher deployments could be studied. When a small ambusher plans an attack on an enemy with strength about four times larger, decisions must be made concerning the location of the ambusher and the relative position of the enemy when the ambusher initiates fire.

Following work by Deitchman to model the ambush situation, a set of Lanchester type equations portraying small force guerrilla engagements were developed by Schaffer. These equations are employed here with claymores, T48, used as the supporting weapons to investigate five ambusher tactical deployments. To analyze various tactical combinations and situations, parameter values were taken from research by other authors, recorded military statistics, and personal combat knowledge. Force sizes were updated by the computer program every five-tenth of a minute of the battle. Success in battle was considered dependent upon infliction of casualties on the opposing force.

The results suggest that a very small ambusher force gains additional advantage by attacking at the front or the rear of the larger ambushed force when the ambushed force is just ready to enter a curve, or attacking the rear of the



convoy just after the end of the convoy passes the curve,  
than attacking at the side of the convoy.



## II. INTRODUCTION

An ambush is a surprise attack from a concealed position on an enemy force. The key word is "surprise." Without surprise, there is no ambush. An ambush is offensive in nature. It is usually a brief encounter and does not require the capture and holding of ground. Ambush may be used in front of and behind the enemy, against both regular and insurgent forces. A series of successful ambushes will make the enemy apprehensive and cautious in movement. Continued success will finally inflict a virtual paralysis on the enemy [8].

The ambush was a popular and successful tactic in the Vietnam War [9], [10], [11]. Of course, the results of engagements are varied and depend upon a number of factors such as the length of the engagement, the positions of the ambushers, and the quantity and quality of intelligence information.

It may be possible to achieve the aim of an ambush by using a very small number of men and covering the selected killing ground with anti-personnel mines such as the claymores or other controlled explosive devices. Once the weapons have been emplaced the ambush can be sprung by one or two men. This layout is particularly effective against targets whose characteristics are well-known.





In this thesis we shall present a deterministic mathematical model of ambush which will take into account possible deployments of the ambusher force. This model will be based on Shaffer's extension to Lanchester's theories of combat and will be used to investigate the effectiveness of alternative ambusher deployment schemes.

Specifically, the type of action which will be studied is an ambush attack where the mission of the attacking force is to disturb and destroy the enemy. It is a brief encounter and does not require the capture and holding of ground. The ambush force will have ample time to select a deployment scheme and prepare its positions. When it initiates fire, it will have planned only a short period of time for the engagement and then withdraw before the arrival of a reaction force or the total recovery of the ambush force. The defensive, ambushed force, has the problem of how to get off the killing ground and effectively engage ambusher force.

The following chapter presents the background and the development of the Lanchester theories. The modification of the Lanchester equations to the ambush model will be discussed in Chapter IV. In Chapter V, we'll examine consequences of various deployment schemes for ambushers. The final chapter presents conclusion and recommendation for further study.



### III. A MATHEMATICAL MODEL OF AMBUSH

The development of a mathematical model of ambushes will begin with the basic Lanchester equations of combat. Modification of the Lanchester equations suggested by Deitchman to model the ambush situation will be discussed. A generalization of Deitchman's model proposed by Shaffer will be used to model the ambush situation.

F. W. Lanchester (1868-1946) was an English engineer. He developed his mathematical formulation for combat between two conflicting forces in an attempt to quantitatively justify Von Clausewitz's Principle of Concentration [7]. Lanchester's law considers two types of fighting. In the case where the opposing sides are not visible to each other, each man is assumed to fire into the area that he believes the opposing force occupies. This results in an attrition rate proportional to the number of men firing and the number of men occupying the area into which men are firing, and vice versa. If  $x$  and  $y$  are force sizes in time and both sides are using this area firing mode, the attrition rates for the two forces are

$$\frac{dx}{dt} = -axy \quad (1)$$

and

$$\frac{dy}{dt} = -bxy \quad (2)$$

where  $t$  is time since the beginning of the battle and  $a$  and  $b$  are called the attrition coefficients for  $Y$  and  $X$  respectively



The constant  $b$  depends upon such things as  $X$ 's rate of fire and the lethality of his weapon, together with the degree to which  $Y$  is protected against area fire.

When (1) is divided by (2) we obtain

$$b dx = a dy. \quad (3)$$

We may integrate both sides of (3) over the time interval  $(0, t)$  to obtain

$$b(x_0 - x(t)) = a(y_0 - y(t)), \quad (4)$$

where  $x_0, y_0$  are the initial forces of both sides, and  $x(t), y(t)$  are the forces at time  $t$ . Equation (4) is called Lanchester Linear Law. It suggests that if one uses area fire against an enemy, there is no advantage to be gained by concentrating one's force [7].

Another case occurs where each unit may take any enemy unit under fire and once a unit destroys an enemy unit, it may shift fire to another enemy unit. In this aimed fire case the attrition rates for the two forces are

$$\frac{dx}{dt} = -ay \quad (5)$$

and

$$\frac{dy}{dt} = -bx. \quad (6)$$

Dividing (5) by (6) and integrating yields the result

$$b(x_0^2 - x^2(t)) = a(y_0^2 - y^2(t)), \quad (7)$$

which is the Lanchester Square Law.

Deitchman has proposed a mixed linear-square law case for ambushes in which the ambusher force fires from concealed





positions with the ambushed force in his full view. The ambusher force, in defending itself, fires at the area it thinks the ambusher force occupies. The attrition rates of the ambushed force of size  $x$ , and the attrition of the ambusher force of size  $y$  are,

$$\frac{dx}{dt} = - Ay$$

$$\frac{dy}{dt} = - Byx ,$$

where  $t$  is the time since the ambush began and  $A$  and  $B$  are the ambushed and ambusher force's attrition coefficients, respectively. These differential equations yield

$$2A[y_0 - y(t)] = B[x_0^2 - x^2(t)],$$

where  $y_0$  and  $x_0$  are the initial ambusher and ambushed force sizes respectively. The simultaneous differential equations can be solved numerically, making possible the calculation of the force size of the two sides at any time during the ambush if the initial force sizes and attrition coefficients are known.

The attrition coefficient of the ambusher force,  $(By)$  is taken to be the rate at which single rifleman in the ambushed force kills the ambushers. Here,

$$B = r_x \frac{A_e}{A_y} ,$$

where  $r_x$  = the rate of fire of each of the ambushed force's weapons,



$A_e$  = the area of target which would produce  
a casualty, and

$A_y$  = the total area which the targets occupy.

The ambushed force's attrition coefficient  $A$  is the product of the rate of fire  $r_y$  of the ambusher force's weapons and the single-shot kill probability of the ambusher force's weapon in aimed fire,  $P_y$ , or

$$A = r_y P_y.$$

These attrition coefficients have not been allowed to vary with time, implying that ambushed force remains in the full view of the ambusher force throughout the engagement and that the ambushed force does not improve its knowledge of the location of the ambusher force.

Marvin B. Shaffer developed a set of Lanchester type equations modeling small-force guerrilla engagements that are typical of the early stages of insurgency [4]. These equations include the effects of supporting weapons and the discipline, or morale of the troops involved. The attrition rate of the ambushed force of size  $x$ , in his model, is

$$\begin{aligned} \frac{dx}{dt} = & -(1 - b_x)k_y(t)y - C_x\left(\frac{y}{x} - 1\right)^2 \\ & - (1 - b_x)\sum_i E_i(t,x)W_i(t) \end{aligned} \quad (8)$$

where  $\sum_i E_i(t,x)W_i(t)$  reflects the support weapons of the ambusher force,  $y$  and  $x$  are the sizes of the ambusher force



and the ambushed force respectively, and  $k_y(t)$  is the ambusher small-arms weapon efficiency coefficient. Here,

$$k_y(t) = \frac{r_y A_T(t) P_{h,k}}{2\pi\sigma_y^2} , \quad (9)$$

where  $r_y$  is the rate of fire of the ambusher force,  $P_{h,k}$  is the conditional probability of killing given a hit, and  $\sigma_y$  is a radial dispersion of a single round fired by ambusher. If  $A_T(t)$  is the area of a target through which the ambusher round will pass, then the probability that a single ambusher round hits the target is

$$\frac{A_T(t)}{2\pi\sigma_y^2} .$$

The change of the target area of a rifleman in the ambushed force is represented by

$$A_T(t) = \frac{A_T(\infty)}{1 - e^{-\alpha t - \beta}} , \quad (10)$$

where  $A_T(\infty)$  is the minimum final presented area of an individual in steady state. Typical values of  $A_T(\infty)$  for prone troops are 0.1 sq.ft. against rifle fire, and 0.5 sq.ft. against high explosive. In the denominator of (10),  $t$  is the time since the ambush began,  $\alpha$  determines the speed at which the ambusher can approach the level of his maximum cover, and  $\beta$  determines the presented area of the individual at the instant the ambush begins. Typical values for  $\alpha$  and  $\beta$  are 6.2 per minute and 0.1, which would imply that the



target achieves approximately 95% of eventual cover within 0.5 minutes.

Return to (8),  $b_x$  is a constant associated with troops discipline [4]. A coefficient reflecting "desertions" associated with being outnumbered is  $C_x(t)$ , for the ambusher, and the term  $-C_x(t)(\frac{y}{x} - 1)^2$  is taken to reflect the ambushed force's rate of withdrawal. The attrition rate contribution produced by the support weapons of the ambusher force is given by,

$$\sum_i E_i(t, x) W_i(t)$$

where  $E_i$  is the weapon efficiencies of the ambusher's  $i$  types supporting weapons over time, and  $W_i(t)$  reflects the supporting weapon strength of type  $i$  over time.

In Schaffer's model the ambusher force attrition rate,  $dy/dt$ , is proportional to the product of the weapon's efficiency coefficient for the ambushed force,  $k_x(y, T)$ , and the number of riflemen in the ambushed force who are firing,  $x$ . It is also proportional to the product of a withdrawal coefficient,  $C_y(t)$ , and the difference between the ambusher force ratio and unity, squared, and we have

$$\begin{aligned} \frac{dy}{dt} = & -k_x(y, t)x - C_y(t)\left(\frac{x}{y} - 1\right)^2 \\ & - \sum_j E_j(t, y)W_j(t). \end{aligned} \quad (11)$$

The small-arms weapons coefficient  $k_x(y, t)$  is explicitly time dependent, since there is a gradual transition from area





fire to aimed fire. A reasonable representation of  $k_x(y,t)$  which simulates this transition is

$$k_x(y,t) = k''(1 - e^{-\gamma t}) + k'y e^{-\gamma t} \quad (12)$$

where

$$k' = r_x \left( \frac{A_e}{A_y} \right) P_{h,k} \quad (13)$$

and

$$k'' = r_x \left( \frac{A_e}{2\pi\sigma_y^2} \right) P_{h,k} \quad (14)$$

When  $t = 0$ , the coefficient takes the appropriate form for area fire  $k'y$ , and when  $t$  is very large the coefficient takes the form for aimed fire,  $k''$ . The constant  $\gamma$  in equation (12) reflects the rate at which the ambushed force can change from area to aimed fire. A value of 0.102 for  $\gamma$  represents an ability to achieve 90% of the aimed fire condition in 23.5 minutes [7].

The term  $C_y(t) \left( \frac{x}{y} - 1 \right)^2$  in equation (11) reflects the ambusher force's rate of withdrawal from the ambush site. The withdrawal coefficient,  $C_y(t)$ , is interpreted by Schaffer as a step function which is dependent on both time and the ambushee - ambusher force ratio. It is defined as

$$C_y(t) = |C_y| [ H(t-t_0) H\left(\frac{x}{y} - 1\right) ] \quad (15)$$

where  $H$  is the unit step function,  $t_0$  is the time required for discipline of an ambusher to deteriorate to the point when he may desert,  $t$  is time, and  $C_y$  reflects the training



and motivation of the ambushers. Thus  $C_y(t)$  is a positive quantity when  $t_j > t_0$  and  $\frac{x}{y} > 1$ , and is zero otherwise.

In (11), the supporting weapons term,  $\sum_j E_j(t,y)W_j(t)$  is essentially of the same form as before.

In the following chapter, Schaffer's ambush model will be modified as necessary to reflect the ambush situations we wish to examine.



#### IV. MODIFICATIONS TO THE AMBUSH MODEL

In this chapter we shall suggest modifications to the Schaffer ambush model to reflect both deployment tactics on the part of the ambusher force, and ambusher use of claymores to set off the ambush. First, five different possible deployment configurations will be presented. Then, after discussing the tactical use of claymores, the Schaffer model will be modified to reflect the effect of a claymore firing to initiate an ambush. This will permit preparations for a numerical comparison of ambusher effectiveness using various tactical deployment schemes.

##### A. SCENARIO AND ALTERNATIVE DEPLOYMENT SCHEMES

The class of ambushes we shall examine involves a daylight attack against a convoy at a 90° curve in a road. The attack will begin with a claymore firing. In selecting the killing ground and deploying the ambushing force, the ambusher commander might consider five alternatives as follows:

1. Attack the front of the convoy as it is just ready to enter the curve, with support from six claymores, three emplaced along each side of the road. We will call this a Type 1 ambush, and a typical scenario is shown in Figure 1.

2. Attack the rear of the convoy just after the end of convoy passes the curve, also with support from three claymores emplaced along each side of the road. This Type 2 ambush is illustrated in Figure 2.



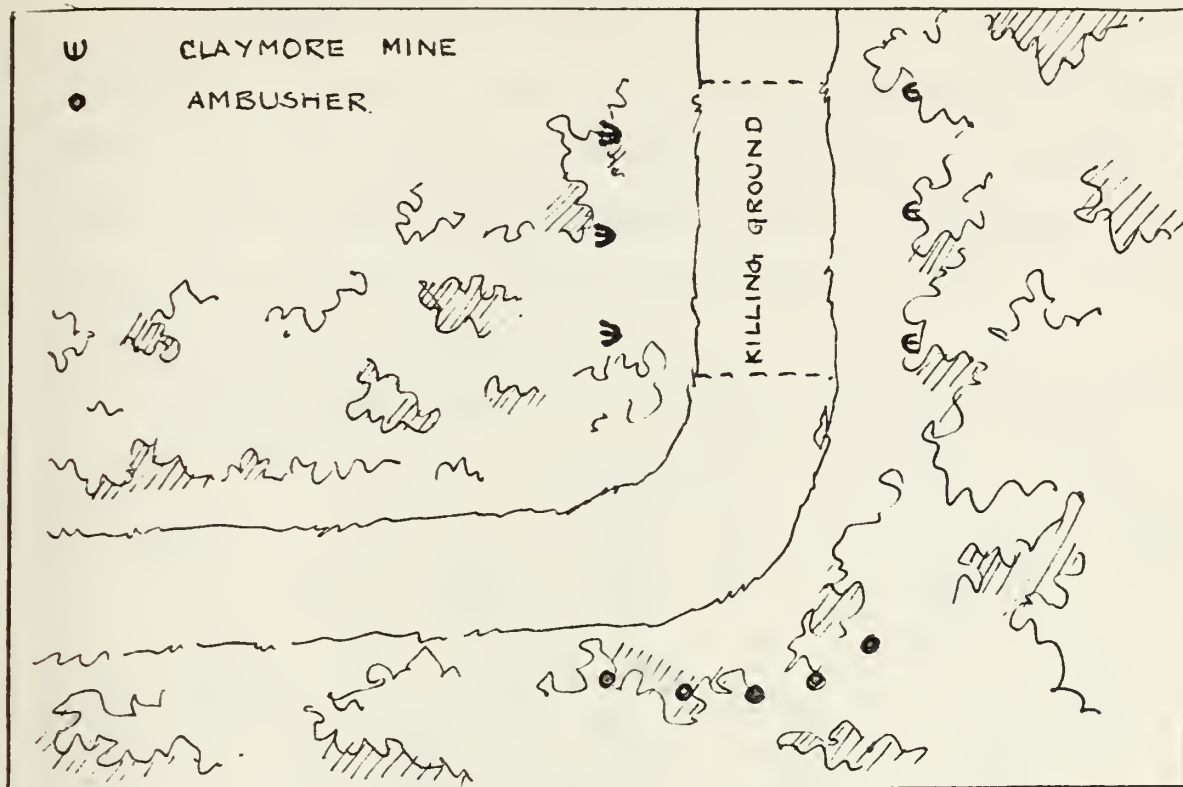


Figure 1. Typical Scenario for a Type 1 Ambush.

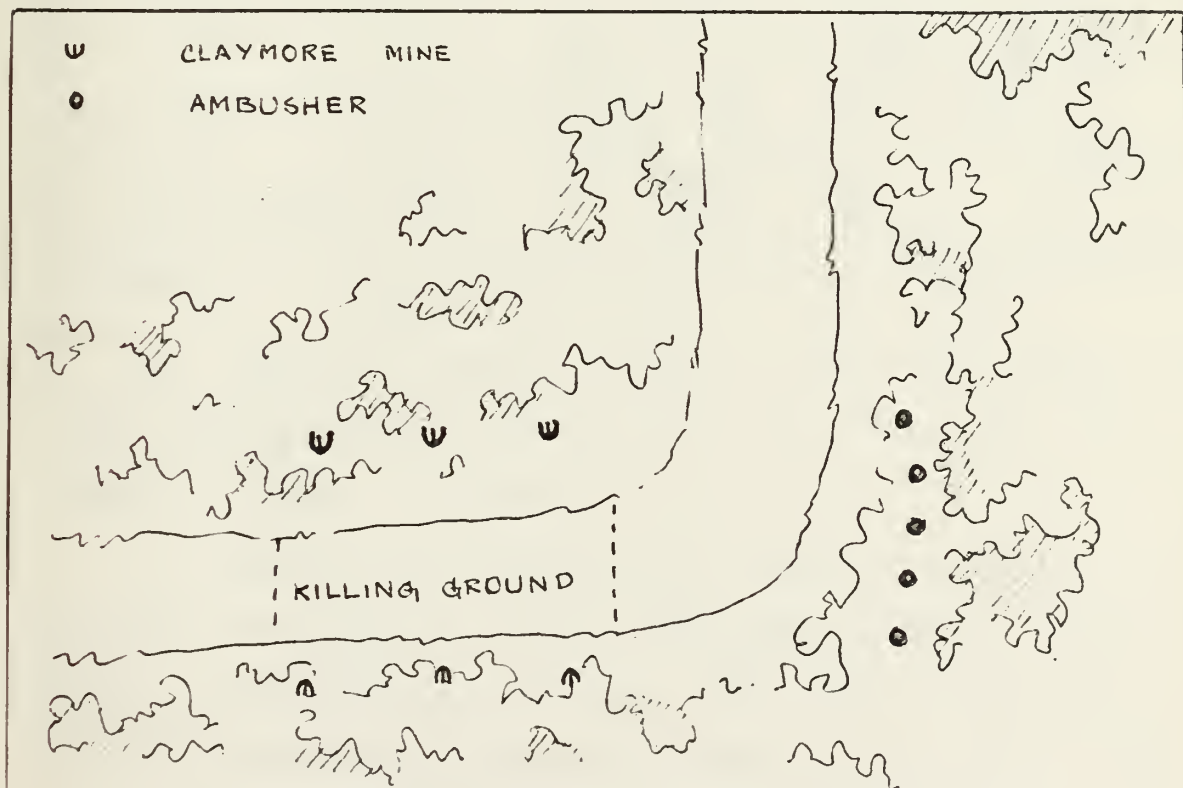


Figure 2. Typical Scenario for a Type 2 Ambush.





3. Attack from the outside of the curve, just as the middle of the column passes the curve, also with three claymores along each side of the road. This will be called a Type 3 ambush and clearly requires that the ambusher force lie in safe positions during the claymore firing. The scenario is shown in Figure 3.

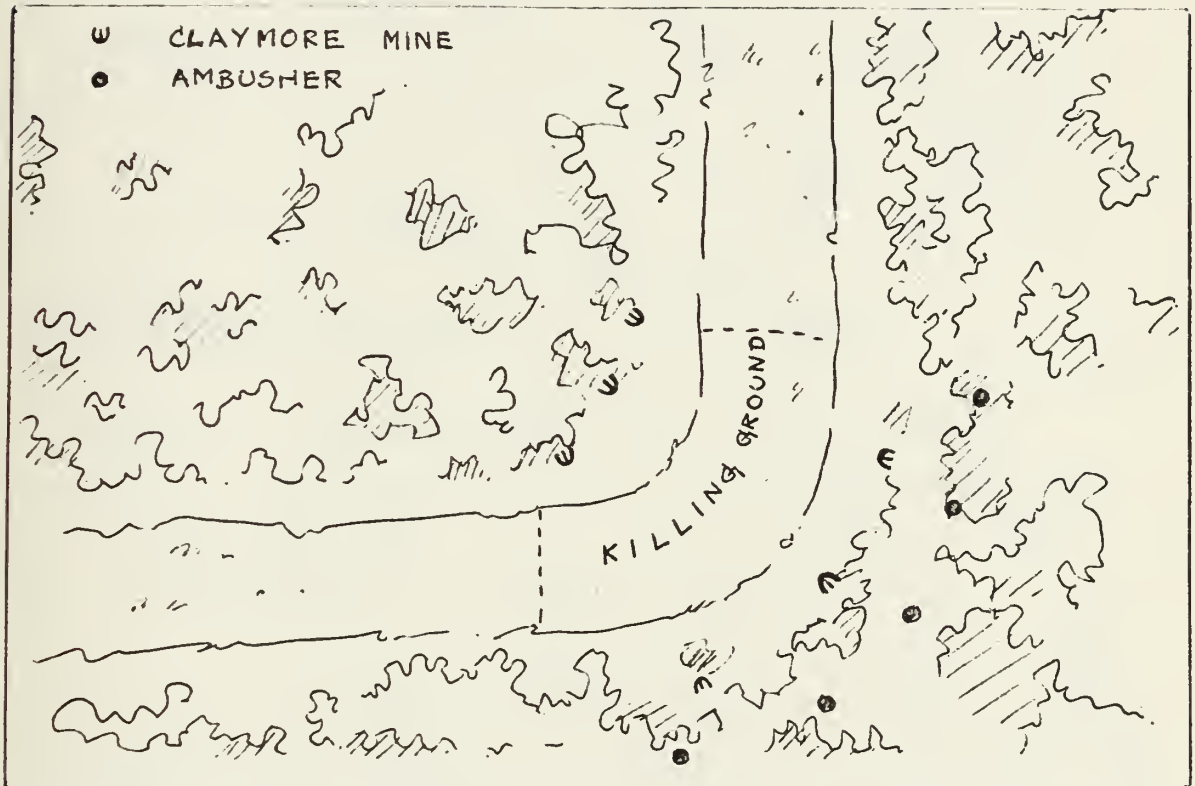


Figure 3. Typical Scenario for a Type 3 Ambush.

4. Attack in a manner similar to the type 3 ambush, but with ambushed force located inside the curve. This Type 4 ambush is shown in Figure 4.

5. Attack either side of the column or convoy before or after entering the curve of the road with six claymores, three on each side of the road. This type 5 deployment is one that would also be used if there were no curve in the road, and is shown in Figure 5.



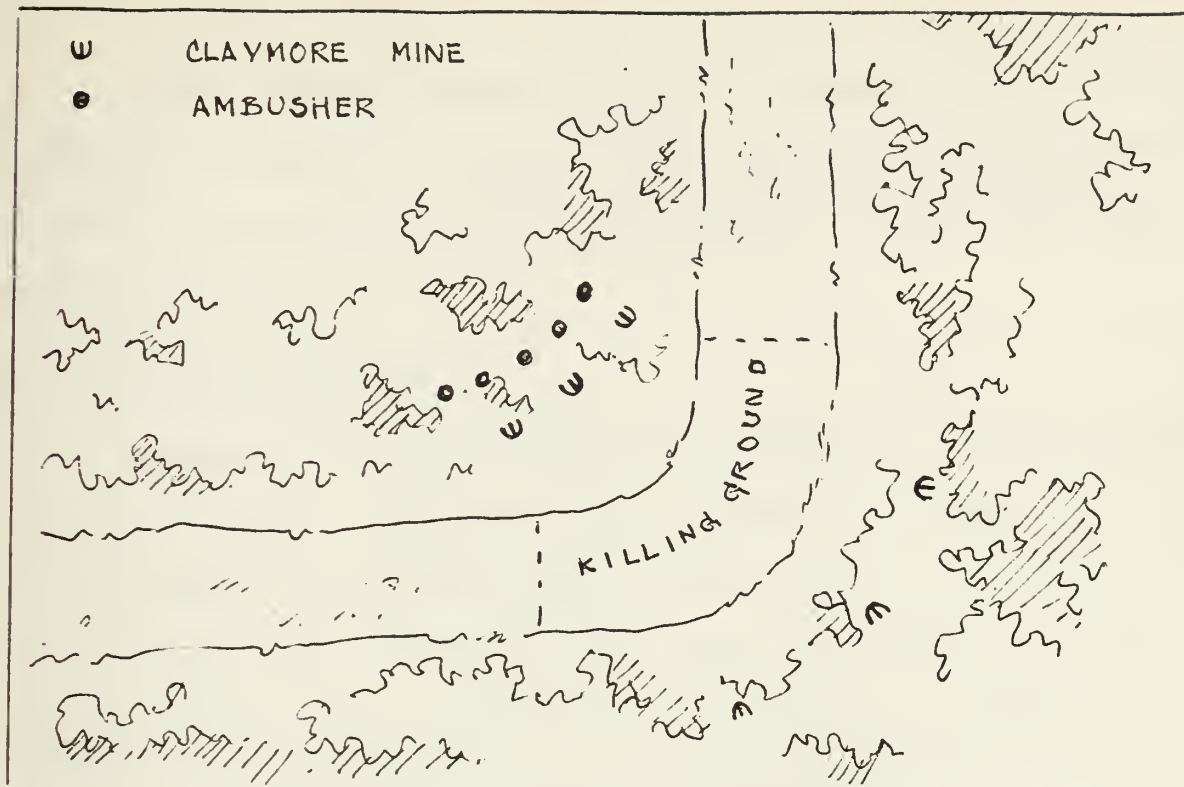


Figure 4. Typical Scenario for a Type 4 Ambush.

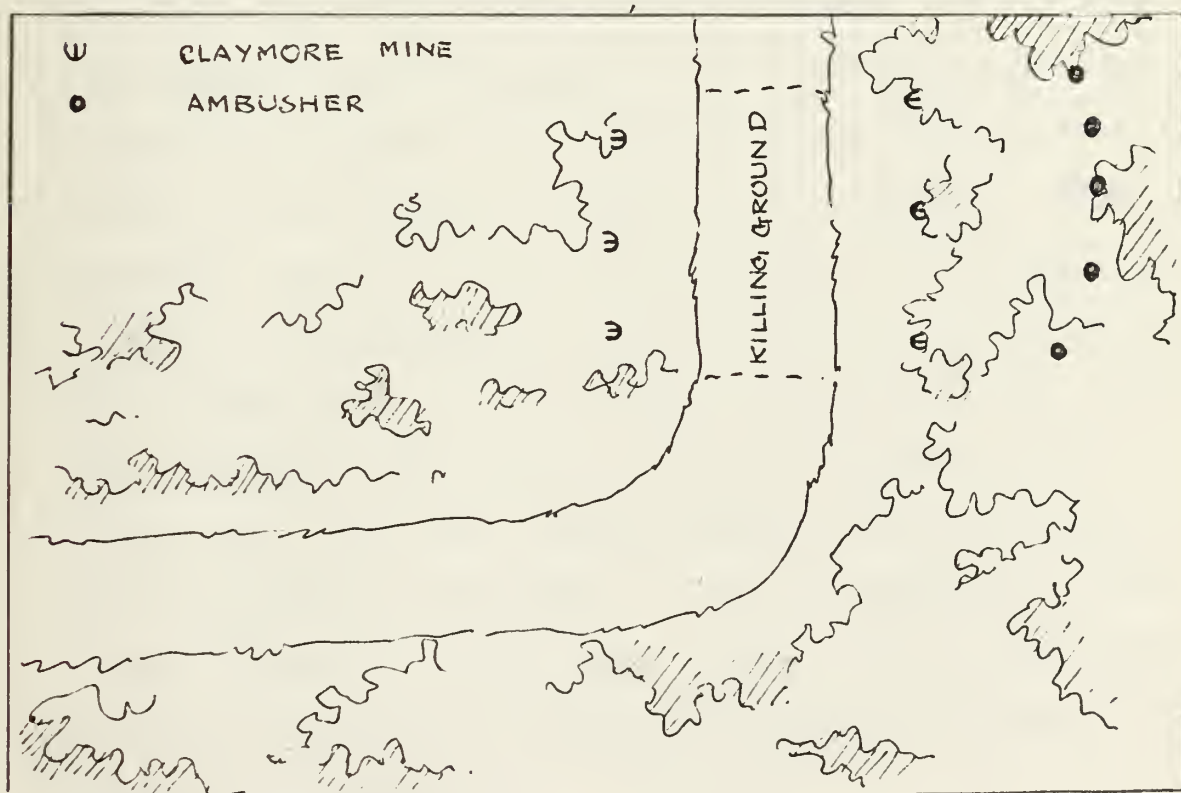


Figure 5. Typical Scenario for a Type 5 Ambush.



After a discussion of the use of claymores we will suggest how parameter values for the attrition rate equations may be selected to reflect the variety in these deployment schemes.

## B. USE OF CLAYMORES

Claymores T48 are used as the ambusher's support weapon in this study. The controlled claymores are emplaced along both sides of the road approximately 100 feet from the center of the road and 80 feet apart, and aimed to the center of the road. In practice, the number of claymores used will depend on the size of the killing ground and the size of the ambushed force. The claymores will be located so that they cover the entire killing ground. It has been recommended that the length of the electrical leads must be longer than 50 feet [1]. Two men, one on each side of the road, will be assigned to control the claymores. When the ambushed force is in the killing ground or the high-value targets of the force are in the center of the killing ground, the claymores on one side of the road will be fired. This is immediately followed by firing the claymores on the other side. The time interval between the two claymores firing should be negligible. Then the ambusher riflemen begin firing at the surviving targets. They are assumed to continue firing until the end of the battle or when the ambusher force withdraws.

The lethality pattern of a T48 claymores, the probability of incapacitation as a function of the location of a person



relative to a detonated T48 claymores under simulated combat conditions has been estimated, and is shown in Appendix B.

### C. ATTRITION RATE EQUATIONS

The ambusher force of size  $y$  is divided into two groups, a group of two men is assumed to control the claymores, and second group of  $y-2$  men assigned to attack the ambushed force. We will assume that the two men who control the claymores are well concealed and not vulnerable to fire from the ambushed force. It is also assumed that there are no support weapons for the ambushed force, so  $\sum_j E_j(t,y)W_j(t)$  can be set at zero. The ambushers are assumed to make a deliberate decision to commence a gradual withdrawal after a specific period of time, thus  $C(t) > 0$ . Then from equation (1), the ambusher attrition can be expressed as

$$\frac{d(y-2)}{dt} = -k_x(y-2,t)x - C_y(t)\left(\frac{x}{y-2} - 1\right)^2. \quad (16)$$

Since it is assumed that no desertions or surrenders take place in the ambushed force, the coefficients  $b_x$  and  $C_x$  can be set at zero. The claymores used by the ambusher are fired only once, at the beginning of the engagement. This is immediately followed by fire from the riflemen of the ambusher force. Since the claymores are fired just before continuous time-dependent attrition begins, the term  $\sum_j E_j(t,y)W_j(t)$  can be set at zero. The initial strength of ambushed force,  $x_0$ , will be reduced to  $x_0(1 - \bar{p}_k)$ , where  $\bar{p}_k$





is the average kill probability (lethality) from the burst of the six claymores.

The estimation of a value for  $\bar{P}_k$  is as follows. It is assumed that all the units of the ambushed force are uniformly distributed over the killing ground, and claymore reliability is 1. The claymores are emplaced 100 feet from the center of the road which is, as a killing zone, 25 feet wide. Three claymores are emplaced on each side of the road, eighty feet apart. This configuration allows effective coverage and safety to the ambusher force. Using the lethality data in Appendix B and allowing for overlapping target coverage, the average may be estimated to be  $\bar{P}_k = 0.518$ . (In the case that the targets are concealed in the vehicles, the probability might be reduced to, say, 0.35.)

The expected number of men in the ambushed force that are killed by claymores is  $x_0 \bar{P}_k$ , and thus attrition after claymore firing will be in accordance with

$$\frac{d(x - x_0 \bar{P}_k)}{dt} = -k_y(t)(y - 2). \quad (17)$$

The ambusher force attrition rate in equation (16) becomes

$$\frac{d(y - 2)}{dt} = -k_x(y-2,t)(x - x_0 \bar{P}_k) - C_y(t) \left\{ \frac{(x - x_0 \bar{P}_k - 1)}{y - 2} \right\}^2 \quad (18)$$

These differential equations provide a model of the ambush situation permitting numerical computation of force sizes at various stage of the ambush. In the next section we shall discuss parameter estimation for rifle fire for each of the five alternative deployments.



#### D. PARAMETER ESTIMATES FOR THE ATTRITION RATE EQUATIONS

For the Type 1 and Type 2 deployment schemes, the number of the riflemen in the ambushed force to fire at the ambusher is limited by the width of the road. In this model we shall assume that at most, seven riflemen can fire at the ambusher force under these conditions, and that casualties will be replaced by the survivors behind.

For parameters in equation (9), (10), (12), (17) and (18) Burnell [3] suggested that these following values are appropriate to the ambush model for estimating  $k_y(t)$ :

$$A_T(\infty) = 1.68 \text{ ft}^2$$

$$\alpha = 0.572 \text{ per minute}$$

$$\beta = 0.4$$

and  $\sigma_y = 10 \text{ miles.}$

These permit computation of  $k_y(t)$  in (17).

For computing aimed and area fire attrition coefficients for fire on the ambushers, Burnell suggests

$$\gamma = 0.516 \text{ per minute}$$

$$\sigma_x = 10 \text{ miles,}$$

and from other sources we have

$$A_e = 0.54 \text{ ft}^2, [6]$$

$$P_{h,k} = 0.80 [2].$$

A maximum rate of fire is 40 rounds per minute, which is the sustained rate of fire of the M-14 rifle [5]. Other studies have suggested that the combat rate of fire could be estimated by multiplying the theoretical rate of fire by 0.5 [3],



thus

$$r_x = 20 \text{ rounds per minute,}$$

and

$$r_y = 20 \text{ rounds per minute.}$$

The final parameter estimate comes from Burnell, who suggests  $C_y = 1.0$  [3].

With these parameter values, the ambushed force effectiveness using aimed fire,  $k''$ , can be obtained by solving equation (11). We assume that the area  $A_y$  which is occupied by ambushers and fired into by the ambushed force is about 800 square yards for Type 1 and Type 2 ambushes. This yields  $k' = 0.0012$  as the attrition coefficient for the ambushed force using area fire.

It should be noted that our treatment of ambush Type 1 and 2 is such that, in the modeling sense, they are indistinguishable. Accordingly, we shall treat them as a single type of ambush.

For Ambush Types 3, 4 and 5 all of the ambushed force survivors can fire by using area fire and then aimed fire with the same parameters as in Type 1 and Type 2 ambushes. What is different is that the area  $A_y$  occupied by the ambusher will vary with the type of attack. For Ambush Type 3 this area is the largest, and for this case we will assume  $A_y = 1,200$  square yards which yields  $k' = 0.0008$ . For Ambush Type 4,  $A_y$  is the smallest, say 730 square yards, yielding  $k' = 0.00132$ . In a Type 5 ambush, ambushes will occupy an



area larger than in the Type 1 and 2 ambushes, but not as large as in the Type 3 ambush where they occupy the outside of the curve. We will assume an area  $A_y = 1,000$  square yards here, or  $k' = 0.00096$ . This value is the same as Schaffer had suggested [4].

Using these values, the simultaneous differential equations developed in Chapter IV may be solved on a digital computer. A computer program was written to solve the differential equations using a Runge-Kutta fourth order numerical integration technique and will be discussed in the next chapter.





## V. NUMERICAL SOLUTIONS TO THE AMBUSH MODEL

A purpose of this thesis is to compare within a limited scenario the effectiveness of alternative deployment tactics for the ambushing force. To do this, a computer program was designed to furnish numerical solutions to the model, thus providing results of simulated engagements fought under different ambusher deployment schemes. This chapter discusses the results of this computer work.

### A. THE COMPUTER PROGRAM

The computer program designed to calculate the outputs of the model uses the FORTRAN IV language and was run on an IBM 360 computer. At the end of every 0.5 minutes of ambush time, the program calculates the casualties for both sides and the current ratio of force strength. It then uses these as inputs for the next time increment. The program runs until either the ambushing force is reduced to the two men who control the claymores, or the ambushed force is annihilated. The computer program is given in Appendix A.

### B. MODEL RESULTS

Using the numerical values for model parameters discussed in the preceeding chapter, the two differential equations comprising the model were solved numerically for each of the ambusher deployment schemes. Results are tabulated in Appendix C and shown graphically in Figures 6, 7, 8, 9, and 10.



Figure 6 shows force sizes over time for ambush Types 1 and 2. Of the various deployment schemes considered, the Type 1 and 2 ambushes were the most successful, yielding a clearcut victory for the ambushers without withdrawal after 3.5 minutes. In other deployment schemes, seven minutes were required for the ambushed force to be defeated.

Results were almost identical for the Type 3 ambush, where ambushers were located outside the curve in the road, the Type 5 ambush, where ambusher were located beside the road, and the Type 4 ambush where ambushers were inside the curve. Force sizes over time for these three deployment schemes are shown in Figures 7, 8, and 9. The model used an area of 29,000 square yards to hold the ambushers in the Type 4 ambush, while the Type 3 and Type 5 ambushes allowed the ambushers areas of 48,000 and 40,000 square yards, respectively. The Type 4 ambush hardly represents "packing" targets (240 square yards of area for each rifleman, initially) and computer results show negligible differences between it and more spacious deployments.

In Figure 10, ambushed-ambusher force ratios are plotted at 0.5 minute intervals during the ambush for the various deployment schemes. Here, the advantages of the Type 1 and Type 2 schemes (where, at most, seven men in the ambushed force could return fire) are clear. It may also be seen that if the ambushers withdraw at 2.5 minutes, all the various deployment schemes will yield rather similar results.



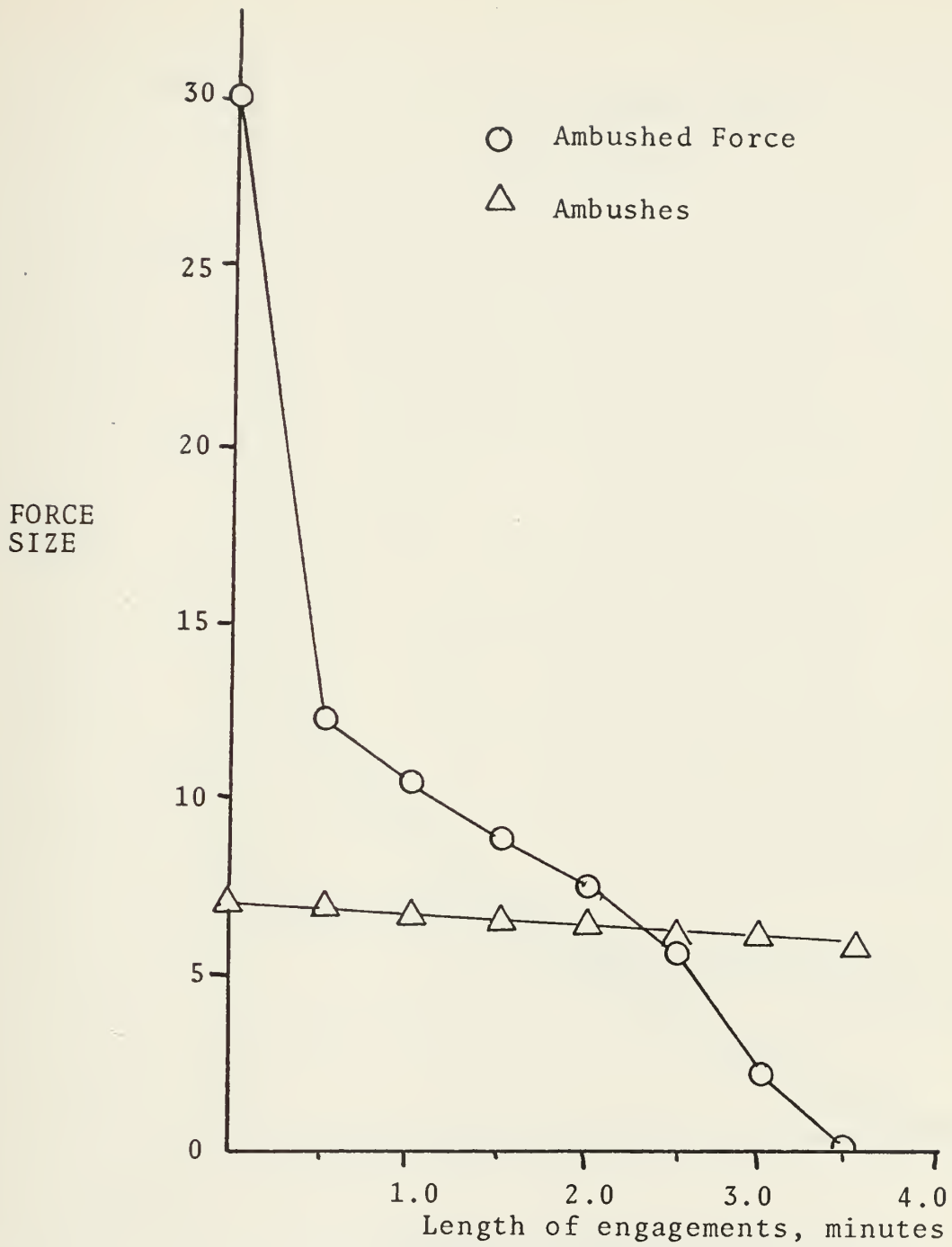


Figure 6. Force Sizes over time for Type 1 and Type 2 Ambushes.



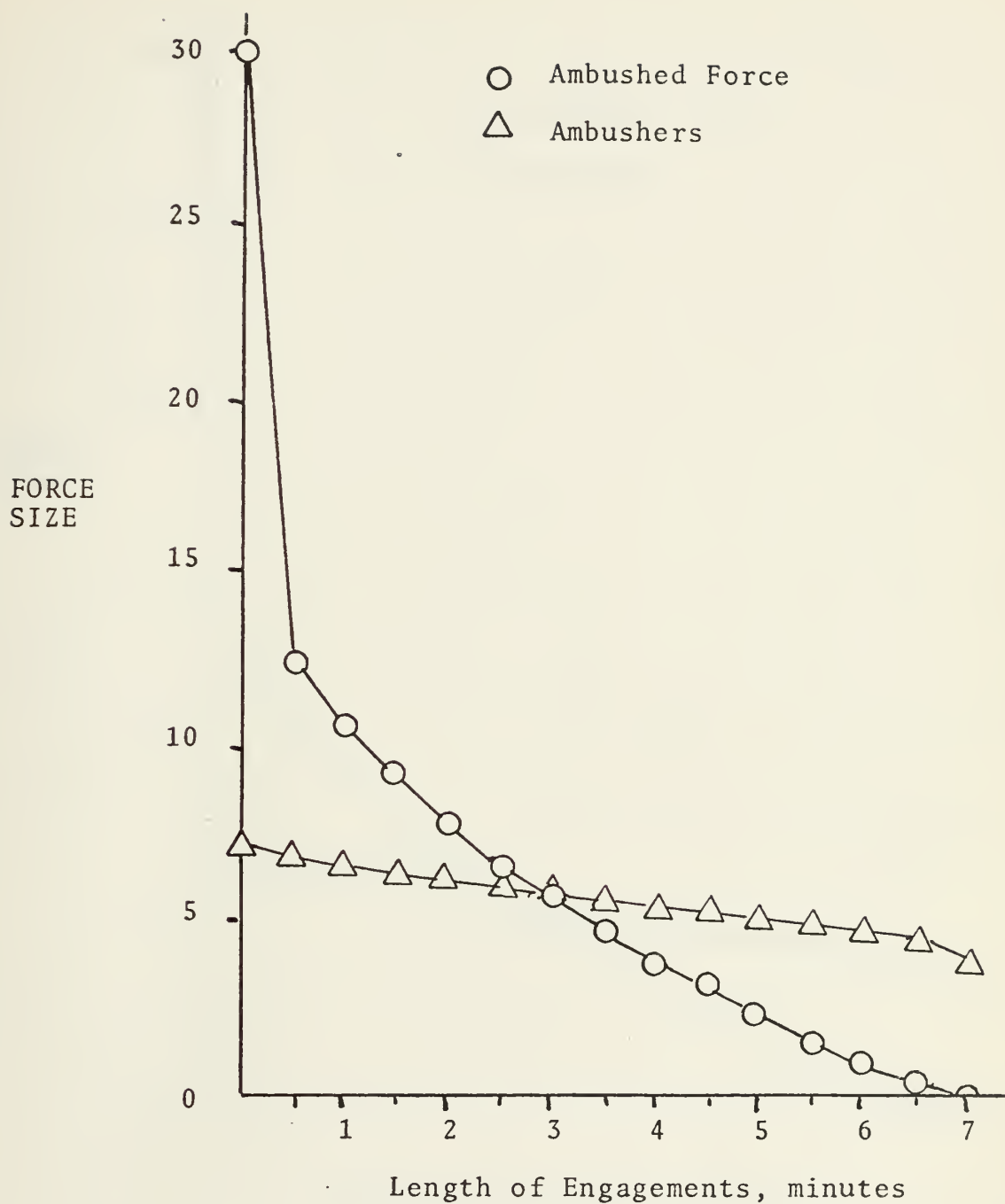


Figure 7. Force Sizes Over Time For Type 3 Ambushes.





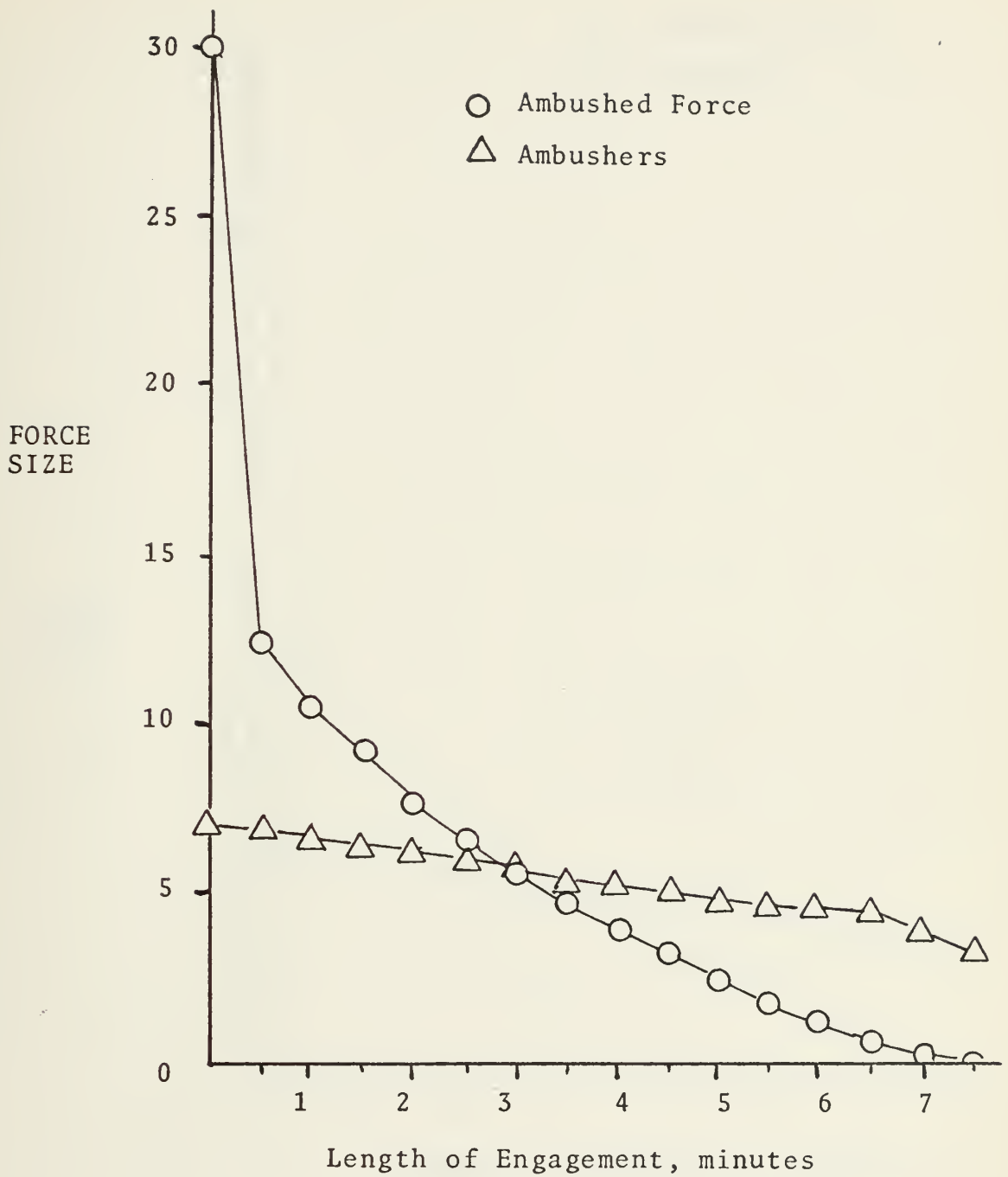


Figure 8. Force Sizes Over Time for Type 4 Ambushes.



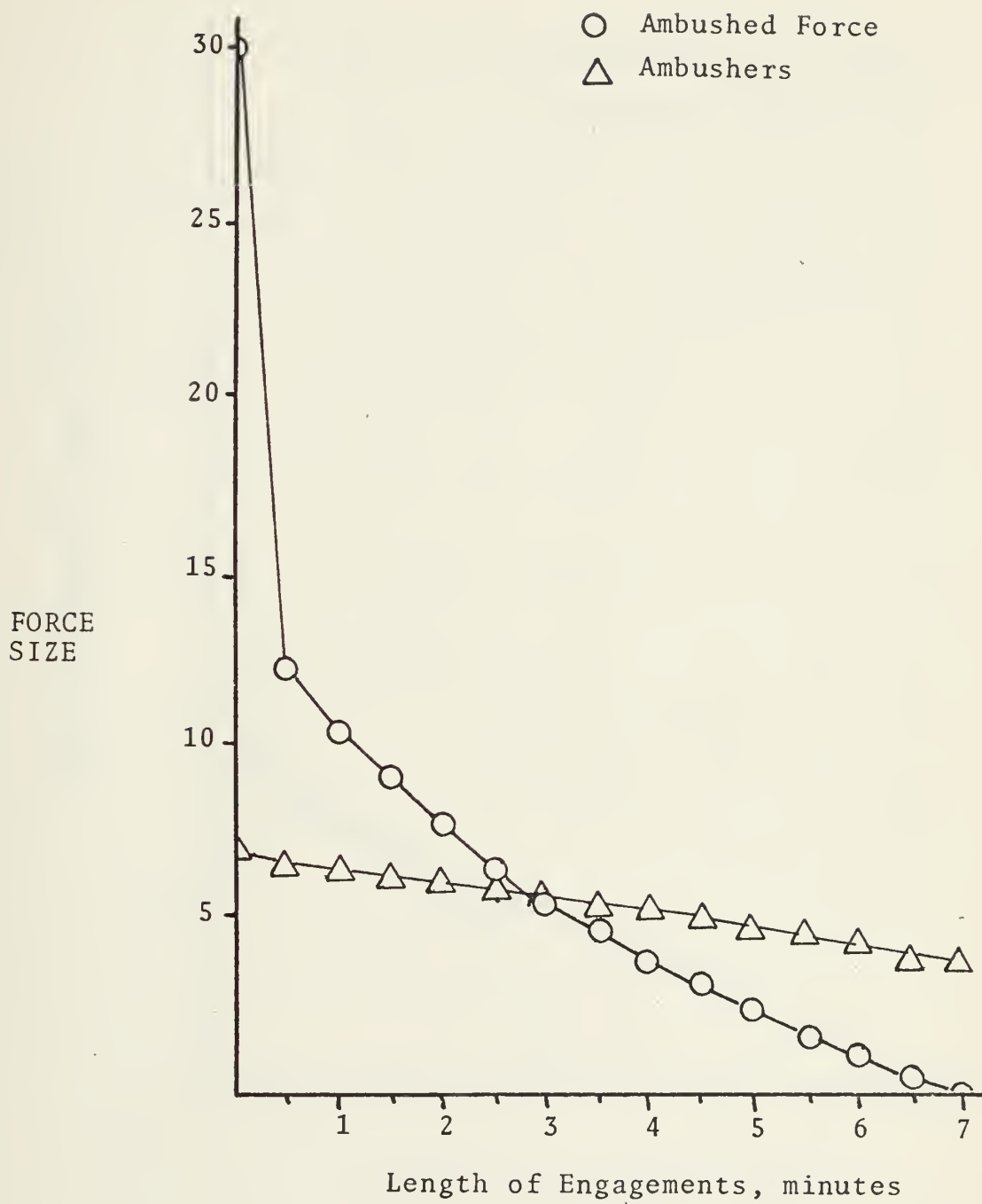


Figure 9. Force Sizes Over Time for Type 5 Ambushes.



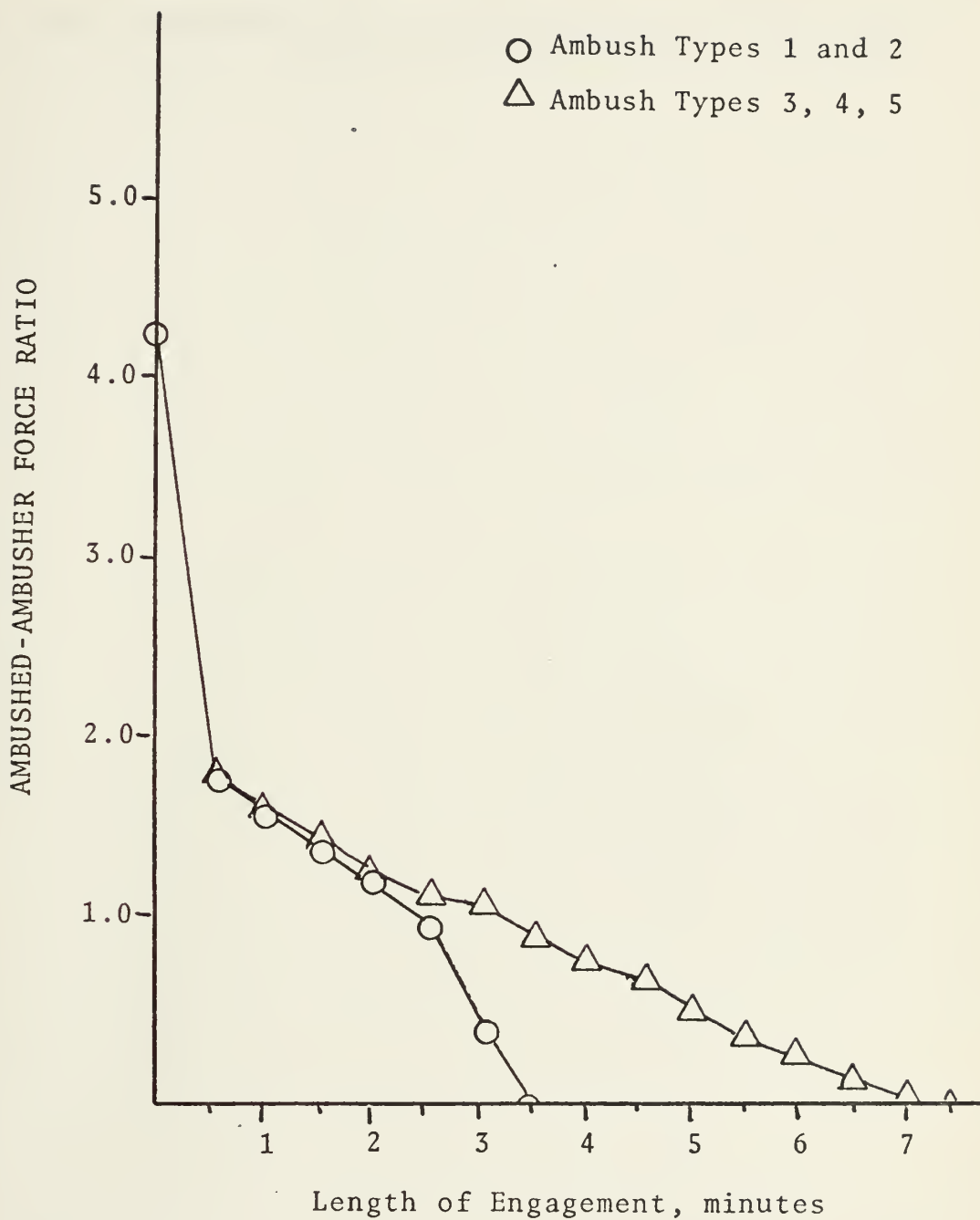


Figure 10. Ambushed-Ambusher Force Ratios for Various Deployment Schemes and Engagement Lengths.



In the next chapter, we will give conclusions from the study and recommendations for further work in this area.





## VI. CONCLUSIONS AND EXTENSIONS

In this chapter general conclusions are made concerning the results from the computer and suggestions are given for extensions. A model has been presented in this thesis to predict the casualties for both sides in an ambush attack on an ambushed force. Because the model is based on Lanchester's theories of combat, the assumptions associated with those theories must be made in the development of this model.

These extensions to Lanchester's theories of combat assume that fire is uniformly distributed over an area or group of targets. Generally, when targets are visible, the unit attempts to fire at all targets (assuming they are all equally important). But, in area fire, fire will usually be directed at the most likely enemy locations rather than over the whole target area. Nevertheless the model developed in this thesis has the supposition that area fire is uniform over the entire area. It is also assumed that the supply of ammunition is not a factor in the problem.

The essential results of the study in this thesis are that there appear to be modest advantages from deploying the ambushing force at a curve in the road so that the ambushers are located so as to fire along the road, either at the front of an oncoming column or the rear of a departing column. This presupposes the presence of the claymores covering the



entire killing zone. In this study using documented claymore lethalties and relatively soft targets, most of the ambushee attrition occurred during the initial claymore firing.

While these results seem quite reasonable, there are many areas of the model which could be further studied. One is the concept supporting weapons. The use of the claymores in this thesis presumes perfect intelligence about size of the enemy force, and they are all fired at the beginning of the engagement. A worthwhile effort would be to use the model with a different type of support weapon such as artillery. Another shortcoming of the model is that it is designed for only single shot weapons. Since automatic weapons are very much a part of modern warfare, altering the model to handle correlated rounds from other than single shot weapons would be most beneficial.

This paper has provided a first analysis of the effects of ambusher deployment on ambush outcomes. There are clearly many other studies which could be done regarding force deployment in ambushes. It is hoped that this thesis will be useful both to those who are concerned with the problems of ambushes and to those who propose to undertake further studies in this area.



# APPENDIX A: COMPUTER PROGRAM FOR THE AMBUSH MODEL

```

00010 //RIDH1257 JOB (0449,0399FT,ROX1),'RIDH',TIME=(01,30)
00030 // EXEC FORTCLGP,REGION.GO=100K
00040 //FORT.SYSIN DD *
00050
00060
00070
00080
00090
00100
00110
00120
00130
00150
00160
00140
00170
00180
00190
00200
00210
00220
00230
00240
00250
00260
00270
00280
00290
00300

C THIS COMPUTER PROGRAM CONSISTS OF TWO PARTS,ONE TO DETERMINE
C THE OUTCOME OF AN AMBUSH,WHEN ATTACK TO THE FRONT AND REAR OF
C THE COLUMN OF AMBUSHED FORCE,THE OTHER TO DETERMINE THE OUTCOME
C OF THE AMBUSH WHEN ATTACK AT THE SIDE OF THE AMBUSHED FORCE.THE
C MAIN PART OF THE PROGRAM READS IN THE DATA AND CONTROLS WHICH
C SUBROUTINE IS CALLED.
C
C COMMON/COM1/TDELI,TMAX,MRED,RED,PBAR/COM2/APHK,ZETA,DELTA/COM3/AK1
C 1,AK2,GAMMA,ROAD/COM4/CN
C
C RMW = INITIAL AMBUSHED FORCE SIZE
C BN1 = INITIAL AMBUSER FORCE SIZE
C ROAD = THE WIDTH OF THE ROAD
C TMAX = TIME AT WHICH THE AMBUSER FORCE MAY BEGIN TO WITHDRAW
C IF OUT NUMBERED
C
C RB = RATE OF FIRE OF THE AMBUSER FORCE
C AT = STEADY-STATE VALUE OF THE AMBUSHED FORCE-COVER
C DELTA = ACONSTANT WHICH DETERMINES THE RATE AT WHICH THE
C AMBUSHED FORCE CAN ATTAIN COVER
C
C ZETA = A CONSTANT WHICH DETERMINES THE PRESENTED AREA OF THE
C INDIVIDUAL IN THE AMBUSHED FORCE.
C
C GAMMA = A CONSTANT WHICH DETERMINES THE RATE AT WHICH THE

```



```

C      AMBUSHED FORCE SHIFTS FROM AREA TO AIMED FIRE.      00310
C      ZIGMA = SING-SHOT RADIAL DISPERSION OF FIRE.      00320
C      AK1 = THE AMBUSHED FORCE WEAPONS EFFICIENCY COEFFICIENT FOR 00330
C      AREA FIRE.      00340
C      AK2 = THE AMBUSHED FORCE WEAPONS EFFICIENCY COEFFICIENT FOR 00350
C      AIMED FIRE.      00360
C      CN = A CONSTANT WHICH DETERMINES THE RATE AT WHICH THE 00370
C      AMBUSER WITHDRAW.      00380
C      TDELL = TIME INCREMENT USED IN RUNGE-KUTTA-GILL INTEGRATION 00390
C      ROUTINE.      00400
C      PHK = SINGLE-HIT KILL PROBABILITY.      00410
C      00420
C      00430
C      00440
C      00450
C      00460
C      00470
C      00480
C      00490
C      00500
C      00510
C      00520
C      00530
C      00540
C      00550
C      00560
C      00570
C      00580
C      00590
C      00600
C      00610
C      00620
C      00630
C      00640

1000 I=1 READ (5,1) RMW,BN1,ROAD
      READ(5,11) TMAX,RB,AT,DELTA,ZETA,GAMMA,ZIGMA
      READ(5,11) AK1,AK2,CN,TDELL,PHK
      1 FORMAT (6X,3(F5.1,2X))
      MRED = RMW
      NBLU = BN1
      3 WRITE(6,3) I,NBLU,MRED,TMAX,ROAD
      3 FORMAT(11,41X,'AMBUSH TYPE',2X,I2,'//,28X,'INITIAL AMBUSER FORCE',
      413,'//,28X,'AMBUSHERS MAX. TIME OF ENGAGEMENT',F5.1,'//,28X,',
      5THE WIDTH OF THE ROAD
      11 FORMAT(12(F10.6))
      A = RB*AT/(2.0*3.1416*ZIGMA**2.0)
      APHK = A*PHK
      WRITE(6,4)
      4 FORMAT ('//,27X,' TIME(MIN) ',3X,' AMBUSHERS FORCE',3X,' AMBUSHED
      1 FORCE ',3X,' AMBUSHED-AMBUSER FORCE RATIO ')
      RED = ROAD/3.0

```

AVERAGE KILL PROBABILITY UNDER THE AREA OF CLAYMORES COVERAGE





PBAR=0.518	
IF (I.GT.2) GO TO 1004	00660
CALL RKUTTA(RMW,BN1,X,Y)	
GO TO 504	00680
1004 CALL MKUTTA(RMW,BN1,X,Y)	
504 I=I+1	00700
IF (I.GT.5) GO TO 1003	00710
GO TO 1000	00720
1003 STOP	00730
END	00740
SUBROUTINE RKUTTA (RMWB,BN1B,XR,YR)	
COMMON/COM1/TDELL,TMAX,MRED,RED,PBAR	00760
T=0.0	00770
X2=RMWB	
THE NUMBER OF AMBUSHED FORCE IS REDUED BY RMWA*P,RESULTED FROM	00790
THE CLAYMORES	00800
RMWB=RMWB-RMWB*PBAR	00810
TWO MEN WHO CONTROL THE CLAYMORES ARE NOT IN THE RANGE OF RIFLE.	00820
BNX=BN1B-2	00830
	00840
	00850
	00860
104 IF (RMWB.LT.RED) GO TO 30	00870
RMV=RED	00880
GO TO 31	00890
30 RMV=RMWB	00900
	00910
RUNGE-KUTTA METHOD BEGINS.	00920
	00930
31 IF (T-0.0) 112,112,103	00940
IF (T-TMAX) 106,105,105	00950
105 IF (RMWB-BN1B) 106,106,107	00960
106 F1=TDELL*TKNT(BNX,T)	00970
G1=TDELL*DNT(RMV,BNX,T)	00980



F2=	TDEL1*TKNT(BNX+G1/2.0,T+TDEL1/2.0)	00990
G2=	TDEL1*DNT(RMY+F1/2.0,BNX+G1/2.0,T+TDEL1/2.0)	01000
F3=	TDEL1*TKNT(BNX+G2/2.0,T+TDEL1/2.0)	01010
G3=	TDEL1*DNT(RMY+F2/2.0,BNX+G2/2.0,T+TDEL1/2.0)	01020
F4=	TDEL1*TKNT(BNX+G3,T+TDEL1)	01030
G4=	TDEL1*DNT(RMY+F3,BNX+G3,T+TDEL1)	01040
GO TO	108	01050
107	F1=TDEL1*TKNT(BNX,T)	01060
G1=	TDEL1*DNTC(RMY,BN1B,T)	01070
F2=	TDEL1*TKNT(BNX+G1/2.0,T+TDEL1/2.0)	01080
G2=	TDEL1*DNTC(RMY+F1/2.0,BNX+G1/2.0,T+TDEL1/2.0)	01090
F3=	TDEL1*TKNT(BNX+G2/2.0,T+TDEL1/2.0)	01100
G3=	TDEL1*DNTC(RMY+F2/2.0,BNX+G2/2.0,T+TDEL1/2.0)	01110
F4=	TDEL1*TKNT(BNX+G3,T+TDEL1)	01120
G4=	TDEL1*DNTC(RMY+F3,BNX+G3,T+TDEL1)	01130
PMY=	RMY+(F1+2.0*F2+2.0*F3+F4)/6.0	01140
BNX=	BNX+(G1+2.0*G2+2.0*G3+G4)/6.0	01150
KMWB=	RMWB-RED+RMY	01160
GO TO	113	01170
112	X1=X2	01190
GO TO	117	
113	X1=FMWB	
117	IF(X1)109,109,110	
109	X1=0.0	
GO TO	120	
110	IF(BNX)111,111,120	01230
111	BNX=0.0	01240
120	XR=X1	01250
YP=	BNX+2.0	
IF(XR)10,10,11		
IF(BNX)12,12,13		
11	RAMN=0.0	01290
10	GO TO 116	01300
12	RAMN=FR/2.0	01310
GO TO 116		01320
13	FR=XR	01330
FB=	YR	
C	THE AMBUSHED-AMBUSER FORCE RATIO.	01360
	RAMN=FR/FB	01370
116	WRITE(6,7)T,YR,XR,RAMN	
7	FORMAT(/,28X,F6.2,8X,F5.3,14X,F7.3,25X,F6.3)	
	T=T+TDEL1	
114	IF(XR)115,115,114	01400
115	IF(BNX)115,115,104	01420
	RETURN	01430
	END	01440



SUBROUTINE MKUTTA (RMWA,BN1A,XA,YA)

COMMON/COM1/TDELL,TMAX,MRED,KED,PBAR  
T=0.0  
X3=RMWA

TWO AMBUSHERS WHO CONTROL THE CLAYMORES ARE NOT IN-  
THE RANGE OF RIFLES

BNX=BN1A-2

THE NUMBER OF THE AMBUSHED FORCE REDUCED BY RMW\*P RESULTED FROM

THE CLAYMORES FIRE.

RMWA=RMWA-RMWA\*PBAR  
RMV=RMWA

THE RUNGE-KUTTA METHOD BEGINS.

```

17 IF (T-0.0) 1,1,3
3 IF (T-TMAX) 4,5,5
5 IF (RMWA-BN1A) 4,4,7
4 F1=TDELL*TKNT(BNX,T)
F2=TDELL*TKNT(BNX,T)
F2=TDELL*TKNT(BNX+G1/2.0,T+TDELL/2.0)
G2=TDELL*TKNT(BNX+G1/2.0,T+TDELL/2.0)
F3=TDELL*TKNT(BNX+G2/2.0,T+TDELL/2.0)
G3=TDELL*TKNT(BNX+G2/2.0,T+TDELL/2.0)
F4=TDELL*TKNT(BNX+G3,T+TDELL)
G4=TDELL*TKNT(BNX+G3,T+TDELL)
GO TO 8
7 F1=TDELL*TKNT(BNX,T)
F1=TDELL*TKNT(BNX,T)
F2=TDELL*TKNT(BNX+G1/2.0,T+TDELL/2.0)
G2=TDELL*TKNT(BNX+G1/2.0,T+TDELL/2.0)
F3=TDELL*TKNT(BNX+G2/2.0,T+TDELL/2.0)
G3=TDELL*TKNT(BNX+G2/2.0,T+TDELL/2.0)
F4=TDELL*TKNT(BNX+G3,T+TDELL)

```

01460  
01470  
  
01490  
01500  
01510  
  
01520  
  
01530  
  
01540  
  
01550  
01560  
01570  
01580  
01590  
01600  
01610  
01620  
01630  
01640  
01650  
01660  
01670  
01680  
01690  
01700  
01710  
01720  
01730  
01740  
01750  
01760  
01770  
01780  
01790  
01800



```

      G4=TDELL1*DNTC(RMY+F3,BNX+G3,T+TDELL1)
      RMY=RMY+(F1+2.0*F2+2.0*F3+F4)/6.0
      BNX=BNX+(G1+2.0*G2+2.0*G3+G4)/6.0
      GO TO 13
1    XA=X3
      GC TO 18
13   IF(RMY)9,9,10
9    RMY=0.0
      GC TO 12
10   IF(BNX) 11,11,12
11   BNX=0.0
12   XA=RMY
18   YA=BNX+2.0
      THE AMBUSHED-AMBUSER FORCE RATIO.
      AMNW=XA/YA
      WRITE(6,14)T,YA,XA,AMNW
14   FORMAT(/,28X,F6.2,8X,F5.3,14X,F7.3,25X,F6.3)
      T=T+TDELL1
16   IF(XA)15,15,16
15   IF(BNX) 15,15,17
      RETURN
      END
      FUNCTION TKNT(BNXK,T1)
      COMMON/COM2/APHK,ZETA,DELTA
      TKNT=-BNXK*APHK/(1.0-EXP(-ZETA*T1-DELTA))
      RETURN
      END
      FUNCTION DNT(RMYD,BNXK,T2)
      COMMON/COM3/AK1,AK2,GAMMA,ROAD
      EX=EXP(-GAMMA*T2)
      DNT=-(AK2*(1.0-EX)+AK1*BNXK*EX)*RMYD
      RETURN
      END
      FUNCTION DNTC(RMYD,BNXK2,T3)
      COMMON/COM3/AK1,AK2,GAMMA,ROAD/COM4/CN
      EX=EXP(-GAMMA*T3)
      DNTC=-(AK2*(1.0-EX)+AK1*BNXK2*EX)*RMYD-CN*(RMYD/BNXK2-1.0)**2
      RETURN
      END
      //GO.SYSIN DD *

```





## APPENDIX B

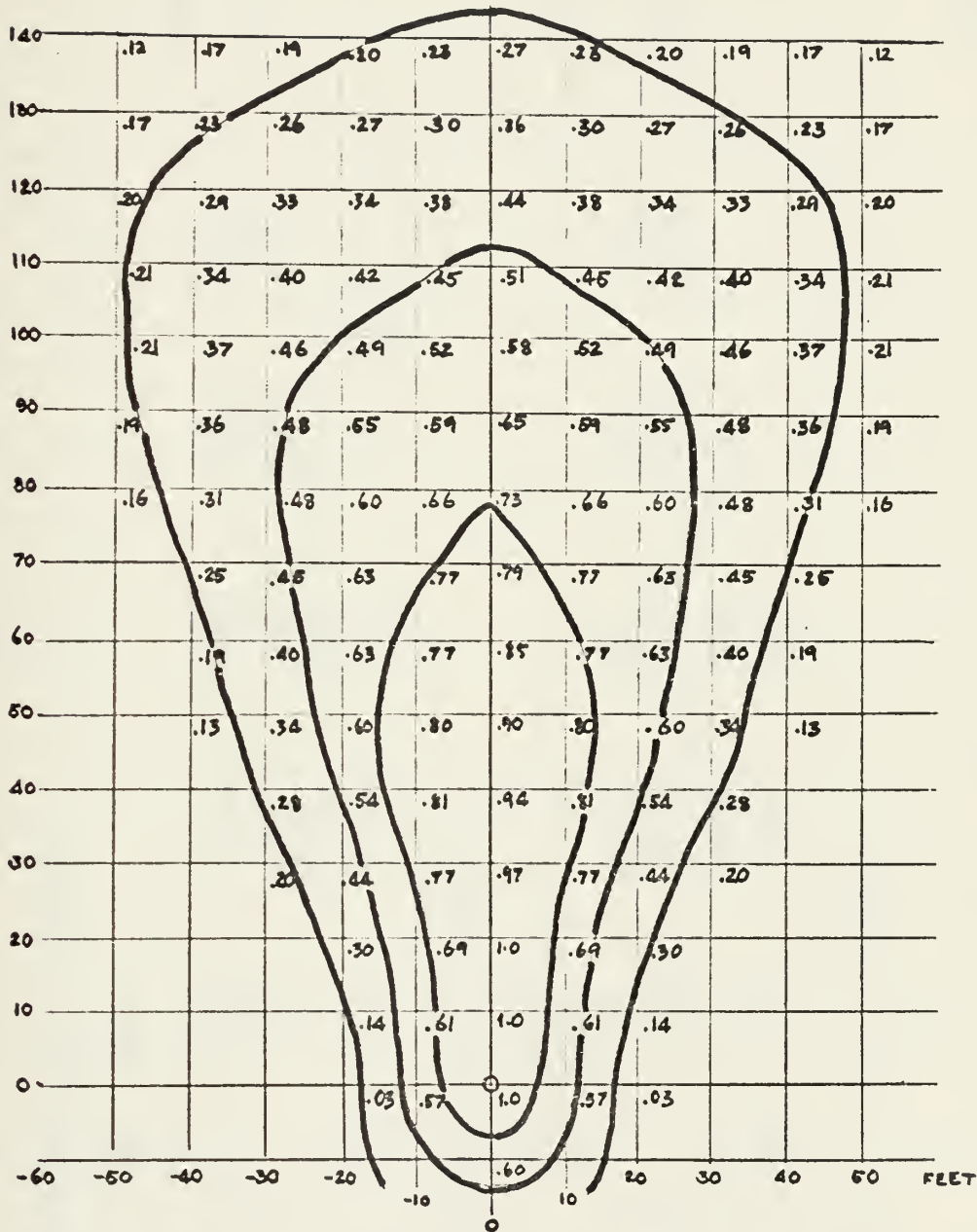


Figure 11 Lethality Pattern of a T48 Claymore

Probability of incapacitation as a function of the location of a person relative to a detonated T48 claymore under simulated combat conditions. The claymore is to be considered located at (0,0) and aimed straight up the page.

Source : "Claymore Employment Techniques Experiment", Memorandum Report, USACDEC, Ft.Ord.Calif, 27 May 1958.



# APPENDIX C: COMPUTER DATA INPUTS USED IN THIS STUDY

## DATA INPUT FOR TYPE 1 AMBUSH

RMW	BN1	ROAD				
30.0	7.0	25.0				
TMAX	RB	AT	DELTA	ZETA	GAMMA	ZIGMA
3.00000	20.0	1.68	0.4	0.572	0.516	2.952
AK1	AK2	CN	TDELI	PHK		
0.0012	07560	1.0	0.5	0.8		

02250

02260

## DATA INPUT FOR TYPE 2 AMBUSH

RMW	BN1	ROAD				
30.0	7.0	25.0				
TMAX	RB	AT	DELTA	ZETA	GAMMA	ZIGMA
3.0	20.0	1.68	0.4	0.572	0.516	2.952
AK1	AK2	CN	TDELI	PHK		
0.0012	07560	1.0	0.5	0.8		

02280

02290

## DATA INPUT FOR TYPE 3 AMBUSH

RMW	BN1	ROAD				
30.0	7.0	25.0				
TMAX	RB	AT	DELTA	ZETA	GAMMA	ZIGMA
3.0	20.0	1.68	0.4	0.572	0.516	2.952

02310

02320



AK1	AK2	CN	TDEL1	PHK
0.0008	0.07560	1.0	0.5	0.8

# DATA INPUT FOR TYPE 4 AMBUSH

RMW	BN1	ROAD		
30.0	7.0	25.0		02340
TMAX	RB	AT	DELTA	
3.0	20.0	1.68	0.4	ZETA
				GAMMA
				ZIGMA
AK1	AK2	CN	TDEL1	
0.00132	0.0756	1.0	0.5	0.572
				PHK
				0.8
				0.516
				2.952
				02350

# DATA INPUT FOR TYPE 5 AMBUSH

RMW	BN1	ROAD		
30.0	7.0	25.0		02370
TMAX	RB	AT	DELTA	
3.0	20.0	1.68	0.4	ZETA
				GAMMA
				ZIGMA
AK1	AK2	CN	TDEL1	
0.00096	0.0756	1.0	0.5	0.572
				PHK
				0.8
				0.516
				2.952
				02380



APPENDIX D: TABULAR NUMERICAL RESULTS OF THE VARIOUS AMBUSH  
DEPLOYMENT SCHEMES

AMBUSH TYPE 1

INITIAL AMBUSER FORCE.....= 7 UNITS  
INITIAL AMBUSHED FORCE.....= 30 UNITS  
THE WIDTH OF THE ROAD = 25 FT.

TIME (MIN)	AMBUSER FORCE	AMBUSHED FORCE	AMBUSHED- AMBUSER FORCE RATIO
0.0	7.000	30.000	4.286
0.50	6.900	12.288	1.781
1.00	6.756	10.518	1.557
1.50	6.578	8.995	1.367
2.00	6.374	7.645	1.199
2.50	6.169	5.738	0.930
3.00	6.008	2.022	0.337
3.50	5.959	0.0	0.0





## AMBUSH TYPE 2

INITIAL AMBUSER FORCE.....= 7 UNITS

INITIAL AMBUSHED FORCE.....= 30 UNITS

THE WIDTH OF THE ROAD = 25 FT.

TIME (MIN)	AMBUSER FORCE	AMBUSHED FORCE	AMBUSHED- AMBUSER FORCE RATIO
0.0	7.000	30.000	4.286
0.50	6.900	12.288	1.781
1.00	6.756	10.518	1.557
1.50	6.578	8.995	1.367
2.00	6.374	7.645	1.199
2.50	6.169	5.738	0.930
3.00	6.008	2.022	0.337
3.50	5.959	0.0	0.0



### AMBUSH TYPE 3

INITIAL AMBUSER FORCE.....= 7 UNITS  
 INITIAL AMBUSHED FORCE.....= 30 UNITS  
 THE WIDTH OF THE ROAD = 25 FT.

TIME(MIN)	AMBUSER FORCE	AMBUSHED FORCE	AMBUSHED- AMBUSER FORCE RATIO
0.0	7.000	30.000	4.286
0.50	6.822	12.302	1.803
1.00	6.607	10.573	1.600
1.50	6.380	9.106	1.427
2.00	6.157	7.819	1.270
2.50	5.947	6.663	1.120
3.00	5.605	5.623	1.003
3.50	5.344	4.697	0.879
4.00	5.154	3.850	0.747
4.50	5.012	3.061	0.611
5.00	4.885	2.316	0.474
5.50	4.733	1.612	0.341
6.00	4.518	0.957	0.212
6.50	4.201	0.371	0.088
7.00	3.730	0.0	0.0



# AMBUSH TYPE 4

INITIAL AMBUSER FORCE.....= 7 UNITS  
 INITIAL AMBUSHED FORCE.....= 30 UNITS  
 THE WIDTH OF THE ROAD = 25 FT.

TIME(MIN)	AMBUSER FORCE	AMBUSHED FORCE	AMBUSHED- AMBUSER FORCE RATIO
0.0	7.000	30.000	4.286
0.50	6.811	12.305	1.807
1.00	6.588	10.581	1.606
1.50	6.356	9.121	1.435
2.00	6.130	7.842	1.279
2.50	5.917	6.694	1.131
3.00	5.559	5.665	1.019
3.50	5.280	4.752	0.900
4.00	5.075	3.924	0.773
4.50	4.924	3.156	0.641
5.00	4.798	2.433	0.507
5.50	4.660	1.749	0.375
6.00	4.471	1.111	0.248
6.50	4.194	0.531	0.127
7.00	3.784	0.037	0.010
7.50	3.160	0.0	0.0



# AMBUSH TYPE 5

INITIAL AMBUSER FORCE.....= 7 UNITS

INITIAL AMBUSHED FORCE.....= 30 UNITS

THE WIDTH OF THE ROAD = 25 FT.

TIME (MIN)	AMBUSER FORCE	AMBUSHED FORCE	AMBUSHED- AMBUSER FORCE RATIO
0.0	7.000	30.000	4.286
0.50	6.819	12.303	1.804
1.00	6.602	10.576	1.602
1.50	6.373	9.111	1.430
2.00	6.149	7.826	1.273
2.50	5.938	6.672	1.124
3.00	5.591	5.636	1.008
3.50	5.325	4.714	0.885
4.00	5.130	3.873	0.755
4.50	4.986	3.090	0.620
5.00	4.859	2.351	0.484
5.50	4.712	1.653	0.351
6.00	4.505	1.003	0.223
6.50	4.200	0.418	0.100
7.00	3.748	0.0	0.0





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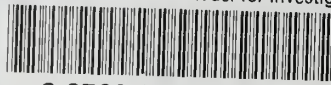
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